AD-A159 350 DETERMINE FORCES REQUIRED TO UPLIFT MARINE PILES DUE TO WATER LEVEL CHANG (U) TECHNICAL UNIV OF DENMARK LYNGBY INST OF HYDRODYNAMICS AND HY F T CHRISTENSEN 1984 1/1

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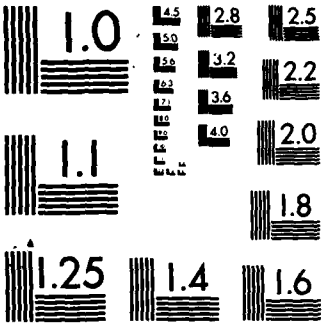

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FINAL REPORT

On contract DAJA45-84-M-0254 and the amendment P00001 thereof.

A total of ten test runs with two set-ups were completed in the test basin in CRREL's Ice Engineering Facility (IEF) during the fall of 1984. The measurements from eight of the tests constitute the first series of measurements of uplifting ice forces ever made in a large tank. Two test set-ups were used simultaneously in the basin; one in each end. Due to the relatively large size of the tank it was possible to run two tests simultaneously without any interaction between them. One set-up used a single pile, and the other set-up used a group of piles. The tests with groups of piles are the first ever performed.

All previous work on uplifting ice forces, theoretical as well as experimental, has focused on the forces necessary to extract a pile from an ice sheet in one pull-out. In the present test series the piles were cycled up and down in hundreds of cycles in order to simulate natural conditions throughout a winter. Piles are frequently seen lifted several meters in areas with only a limited range of water level fluctuation (0.2 meter). Thus, a successive mechanism m st be responsible for this step-wise jacking of piles. Identification of the involved successive processes will enable improved engineering design solutions. CRREL and the Institute of Hydrodynamics and Hydraulic Engineering have gathered field experience in the United States and Denmark, respectively, over the years. For the first time some of the successive mechanisms that have been observed in the field have also been verified in model tests.

The results obtained from this test program form a new and important basis for evaluating the theoretical formulae which have long been used for predicting uplifting ice forces. The existing theoretical formulae for predicting the uplifting ice forces in a group of piles have not previously been tested.

Fluctuating water levels will cause bending cracks to appear in the floating ice cover around frozen-in piles. These cracks will refreeze and regain their strength with time. This will affect the pile jacking process.

The refreezing of cracks formed by bending of floating ice sheets was also investigated in the course of this project. It has been shown that the refreezing process can be adequately described with a relatively simple theory based on the heat transfer in the vicinity of a crack. A dimensionless description of the process has been formulated in order to make the results generally applicable. A total of fifteen tests have been used to investigate the refreezing process. From the test results an empirical formula for predicting the relative flexural strength of a partially refrozen crack in an ice sheet has been derived. The derivation together with a description of the experiments has been published by F.T. Christensen in Progress Report 62 from the Institute of Hydrodynamics and Hydraulic Engineering, Technical University of Denmark. (A copy is enclosed). A scientific article on the subject has been prepared and accepted for publication in the international journal "Cold Regions Science and Technology". It will appear in the journal in early 1986. The refreezing of cracks has not previously been investigated, and the results of this study are therefore of great interest. The refreezing is important to a variety of problems encountered in ice-infested waters, e.g. bearing capacity problems, river ice break-up problems etc.

The results of this program may be summarized as follows:

a) Evaluation of theoretical formulae for predicting the ice-induced vertical forces in a pile;

b) Evaluation of theoretical formulae for predicting the ice-induced vertical forces in an interacting group of piles;

c) Laboratory verification of successive processes responsible for step-wise jacking of piles by ice;

d) Establishment of a theory on the refreezing of cracks, and derivation of an empirical formula to predict the relative flexural strength of a partially refrozen crack.

The aim of the program has been fulfilled, and a detailed scientific report for a CRREL-publication will be prepared. Furthermore, the results will be presented in a Ph.D. thesis to be submitted in the fall of 1985. The thesis will be published by the Institute of Hydrodynamics and Hydraulic Engineering in early 1986.

Flemming Thunbo Christensen

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